

# NASA NDE WORKING GROUP NEWSLETTER

August 1996

Quarterly Newsletter

VOL. 4, NO. 3

WWW URL address: <http://ndea.jpl.nasa.gov/>

## CODE Q NDE PROGRAM MANAGER MESSAGE

*Edward R. Generazio, LaRC, 804-864-4970*

*Ed\_Generazio@qmgate.larc.nasa.gov*

NNWG Members: This fiscal year we will use a dramatically different process for initiating tasks for FY97. Details of the process will be forthcoming in early August. Let's all look forward to having a good year and meeting our FY97 milestones. This quarter, we successfully advocated the early start of three NDE tasks while providing additional substantial funds for upgrading our NDE equipment infrastructure. We also are planning a small growth in the NDE program over the next 5 years. We will need to maintain, enhance, and report on our highly productive activities.

## NNWG NEWSLETTER IS BECOMING ELECTRONIC

This is the last hardcopy issue of the NNWG Newsletter. Due to the high cost, a decision was made to change our Newsletter to an electronic format only. The new version of the Newsletter will have enhanced technical details and will be accessible to NASA only and will serve as an internal NASA NDE Working Group forum of communication and archival. A publically available version will be accessible at the LaRC Website address: <http://zeta.larc.nasa.gov/docs/nesb.html>

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## NNWG CHAIR MESSAGE

*George Y. Baaklini 216-433-6016*

A Telecon was called to order by the NNWG Chair George Baaklini at 2:05 p.m. EST, July 18, 1996, and involved 14 attendees, including: Yoseph Bar-Cohen, JPL; Jim Chern and Brad Parker, GSFC; John Larson and Rick Russell, KSC; Linda Clark Sam Russell and Bob Neuschaefer, MSFC; Bill St. Cyr, SSC; John Segreto, ARC; Marie Havican, JSC; Ed Generazio, LaRC; and George Baaklini and Don Roth, LeRC. The following topics were discussed:

**Status of the FY'97 Budget Planning Exercise (BPE) call** - Ed Generazio has already funded 3 additional NDE tasks (2 from KSC and one from MSFC) from FY96 resources. He has identified remaining tasks as possible FY'97 new starts.

Some of these tasks need further support highlighting "Flight critical", "Mission critical", "substantial cofunding", and "leveraging industry input and interests". Next year, according to Ed, we will have no popcalls the way we know it. Instead, we will have tasks worked and identified within the group. The NDE thrusts will be on Human Space Flight and Aeronautics.

**Costings of FY96 programs** - RTOPs should be costed at the level of at least 75% of the FY96 fund by Sept. 30th with 25% carry over to be spent in early FY97. Ed is planning to improve the NDE budget via slow growth through to FY'99.

**NDE infrastructure Support** - The infrastructure support is expected to reach the Centers soon. The procurement should be costed in two months from receipt of funds. To assist in making this a smooth transition, each Center was asked to submit to Ed the name and phone number of the Center's Administration Management Specialists. All the names from each center that were received by LeRC were forwarded to Ed by COB 7-19-1996.

**Decision on the future of the Newsletters** - Ed stated that in FY'97 the Newsletter in the hardcopy format will be a thing of the past. The new way of communicating news in FY97 will be electronic. Ed will initiate the input and it will be modified/added-on by each of the working group members. A publically accessible version will be available at the LaRC Website.

**NNWG workshop at JPL** - The official date for the 4<sup>th</sup> NNWG workshop was set for Feb. 25 and 26, and on the 27th there will be a tour of JPL and a Vendors' Exhibit (not part of the NNWG Workshop agenda).

**Noinations for a Chair and Vice Chair for the Code Q committee** - Bob Neuschaefer has asked the members of NNWG to nominate others or self for these two positions by August 1st, hoping to have the votes in by August 14, and to report results by August 15.

**Focal point for ISO 9000** - Marie Havican was appointed to serve as the focal point, where Yoseph Bar-Cohen and John Larson are going to help in establishing and expanding on the NPD plan for NDE.

**Jim Chern's proposal on "NDE Personnel Qualification and Certification Development Process"** - Jim Chern's proposal was e-mailed to all the members prior to the Telecon, and Jim and Ed are expecting a feedback from all of us hopefully by the next Telecon as to whether we should support this activity or not.

**Orbiter Sub-Committee** - briefing by Rick Russell was scheduled for next Telecon, sometime in Sept.

## **NNWG HIGHLIGHTS**

### **RTOP IS NOW BUDGET PLANNING**

**EXERCISE (BPE)** - NASA HQ has a new process for RTOPs, now called BPEs (Business Plan Exercise). A large package was sent out to all the Centers to provide a guide. In parallel, Ed Generazio sent a package to each of the members of NNWG specifically addressing the BPE call for NDE proposals. The proposals are due by to the delegated manager by August 12, 1996 and they represent a new way for soliciting Code Q request for proposals with emphasis on deliverables that directly support NASA's missions.

## **ORBITER NDE SUB-COMMITTEE (ONSC)**

**Rick Russell, 407-861-4168 [rrussell@tvnet.ksc.nasa.gov](mailto:rrussell@tvnet.ksc.nasa.gov)**  
**THE ORBITER NDE SUB-COMMITTEE (ONSC) HELD A TELECON ON JUNE 17, 1996** - A progress report on the consolidation of standards was given by Chris Davis, NASA KSC. All members were encouraged to continue supporting this effort. The topic of transportation of standards was also discussed.

The group then welcomed new participants from Rockwell Canoga Park who gave presentations on their use of Real Time Radiography and the development of X-ray film digitization. The team members from KSC were especially appreciative of

this information since they are interested in obtaining a digitization system.

## NNWG PERSONNEL NEWS

**Don Roth, winner of the R&D 100 award.**



**Congratulations to Don J. Roth, LaRC for wining the R&D100 Award** - The NASA NDE Working Group (NNWG) would like to congratulate Don Roth for wining the R&D100 Award. This award is for the development of a single transducer imaging method for thickness-independent velocity measurements. Congratulations Don!!!.

**Yoseph Bar-Cohen elected ASNT Fellow** - In April 96, the ASNT Awards Committee selected and the Board of Directors approved Bar-Cohen as the recipient of the ASNT *Fellow Award*. The Award will be given officially at the ASNT Fall Conference that will be held in Oct. 96 in Seattle, Washington.

## NASA CENTERS NEWS

### JPL

*Yoseph Bar-Cohen, 818-354-2610, yosi@jpl.nasa.gov  
<http://nasa-nde.jpl.nasa.gov/jpl-nde/nde-aa-l/nde-aa-l.htm>*

**VISIT TO McCLELLAN AIR-FORCE BASE** - In June, Soheil Nazarian, University of Texas at El Paso (UTEP), and Yoseph Bar-Cohen visited McClellan Air Force Base for facts finding regarding Air Force NDE needs and their most recent testing technology. This effort is part of an ongoing contract with AFOSR. Al Rogel hosted

this visit and gave the visitors a tour of the aircraft maintenance facility as well as the various NDE laboratories. The laser ultrasonic system, that became operational in March 1996, received the most attention during this visit. This is a new system and McClellan AFB was the first to implement it to a practical use. This new system follows a history of taking a lead in implementing new technology at McClellan AFB. This AFB has been the first to install an advanced robotic facility for large area inspection using X-ray and neutron radiography where a full aircraft is being tested without disassembly. Al Rogel is following closely the recent development of the JPL's MACS technology.



Soheil Nazarian, UTEP (right) and Yoseph Bar-Cohen, JPL (Left) hosted by Al Rogel (middle) at McClellan AFB.



Tom Kwan, McClellan AFB, is operating the new laser ultrasonic scanner.

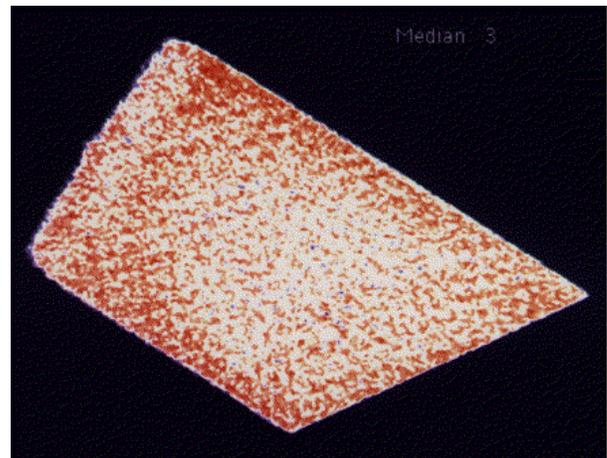


Multifunction Automated Crawling System (MACS) on the C-5 airplane [Patent Pending].

**MACS TO BE DEMONSTRATED TO A JPL HIGH LEVEL DoD VISITOR** - On August 15, 1996, the Honorable R. Noel Longuemare, the Principal Deputy UnderSecretary for Acquisition & Technology, Department of Defense will visit JPL for a day to see demonstrations of selected technologies. Out of the wide variety of impressive technologies that JPL has developed in recent years, the Honorable visitor chose several items for his agenda including the Multifunction Automated Crawling System (MACS). MACS [Patent Pending], which was reported in prior issues of this Newsletter, is a miniature crawler that was designed for inspection of aircraft structures using telerobotic technology that is developed for Mars exploration. It uses ultrasonic motors for its mobility and vacuum suction cups for controlled adherence. In parallel to the ongoing efforts to enhance the capability of MACS, an initiative is underway to adapt this technology to space applications. Jointly with Bill Prosser, LaRC, a wireless acoustic emission sensor technology is being explored. Whereas, jointly with Min Namkung, an initiative is being considered for the development of an Autonomous Miniature TeleRobotic Inspector (AMTRI).

**NDE OF COMPOSITES COLLABORATION WITH LeRC AND KSC** - Under a Code Q RTOP, JPL is developing jointly with Eric Madaras, LaRC, a system for Ultrasonic NDE of the Integrity and Performance of Composites

(UNIPC). A user-friendly software for material analysis and C-scan mapping is being developed. The end goal of this program is to demonstrate the performance, simplicity of operation and practicality of UNIPC by testing NASA critical composite structures. In order to nondestructively examine the material density and porosity content, the use of CT analysis to supplement ultrasonic measurements has been explored in collaboration with George Baaklini, LeRC and, John Larson, KSC. Graphite/epoxy defect-free controlled samples (provided by John Taylor, Rohr) as well as samples with extensive porosity that were made for Mars Pathfinder are being studied. Series of tests were made and the density distribution was mapped in various cross sections of the samples.



CT image of the density distribution in a reference graphite/epoxy sample.

**COMPOSITE MATERIALS ARE NOW A \$47M PROGRAM AT JPL** - Recent review of the JPL level of programs that employ composite materials showed a sharp rise to a level of more than \$47M. This is a significant milestone since space exploration is very sensitive to the reliability of the construction materials and there is no second chance to a failure. The significant improvement in the material quality, durability and inspection led this recent increase. To assure continuous improvement of the inspection capability and reliability while reducing inspection cost, JPL is involved in a joint RTOP with LaRC to develop a system of an Ultrasonic NDE of the Integrity & Performance of Composites (UNIPC).

**INTEGRATED HEALTH MONITORING SYSTEM FOR S/C APPLICATIONS** - In June, Innovative Dynamics, Inc. (IDI) completed the Phase II SBIR contract with JPL. The contract is entitled "Development of Integrated Health Monitoring System for Spacecraft Applications," and the JPL Technical Monitor is Yoseph Bar-Cohen. A system was developed to monitor inception of damage in composite structures, where an imbedded set of transmitters and receivers are used to excite vibrations, as well as detect and analyze them.

Tianji Xue joined the JPL's NDE&AA Team as a Postdoc.



**TIANJI XUE, A NEW MEMBER OF THE JPL's NDE&AA TEAM** - In June, 1996, Tianji Xue joined the JPL's NDE&AA Team after he completed the requirements of his Ph. D. degree. Xue received his BS degree in Optical Engineering from the Beijing Institute of Technology, and his MS and Ph.D. degrees in Electrical Engineering from Iowa State University. Xue has experience in ultrasonic wave propagation with application to nondestructive evaluation semiconductor and thin film devices design and characterization; optical system design, image formation and processing; and numerical modeling of electromagnetic. At JPL, Xue is working on NDE of Composites as well as the development of electroactive polymers for muscle actuators

**THE NDE & ADVANCED ACTUATORS (AA) TEAM RECORDED 4 PATENTS PENDING SINCE FEB. 1996** - Four New Technology Reports of the NDE&AA team were officially submitted to the Patent Office in Washington and are now Patent Pending. These inventions involve the use of piezoelectric elements as actuators and they include:

Y. Bar-Cohen, "Pump Using Pistons and Valve Made Of Electroactive Actuators", Patent Pending, CIT 2427, Feb. 9, 1996.

Y. Bar-Cohen, S.-S. Lih and W. Grandia, "High Torque Ultrasonic Motor System Using a Series of Connected Individual Motors and a Stack of Piezoelectric Drivers," Patent Pending, CIT 2428, Submitted on April 17, 1996.

Y. Bar-Cohen, B. Joffe and S.-S. Lih "Flexural Traveling Wave Pump Using No Physically Moving Parts", Patent pending, CIT 2456, Submitted on June 25, 1996.

Y. Bar-Cohen, B. Joffe and P. Backes "Multifunction Automated Crawling System (MACS)", Patent Pending, CIT 2432, Submitted on August 1, 1996.

**NDE OF COMPOSITE STANDARDS - JPL** just completed issuing a series of NDE of composite standards. These standards include a general document and two specific ones that cover ultrasonics and radiography. These documents issued by Bar-Cohen were reviewed NASA-wide and by selected individuals from the industry and DoD. This recent effort was taken as the first step before transition of these standards to non-government standard (NGS) organizations. The general trend in government forming standards is to issue a document only when no other exists and to transfer the existing to NGS organizations. This trend was also one of the decisions that were made by the NASA M&P Standards Working Group in its last meeting that was held in July 1996 at KSC.

**NAMKUNG, LaRC, VISITED THE JPL's NDE&AA LAB TO DISCUSS COOPERATION IN MINIATURE ROBOTIC NDE** - In July, Min Namkung visited the JPL's NDE & AA Lab to discuss a cooperation in the area of miniature robotic NDE. The extensive JPL involvement in TeleRobotics and its successful development of MACS produced enabling technology for an Autonomous Miniature TeleRobotic Inspector (AMTRI). AMTRI is currently being designed for space applications and

whenever possible it will use commercially available components. The CrackFinder and controlled adherence are some of the technologies that LaRC is offering to this potential cooperation.

**GEORGE MATZKANIN VISIT THE NDE&AA LAB** - In July, George Matzkanin, Director, NTIAC, Austin, TX, visited the NDE&AA Lab. The purpose of the visit was to discuss potential collaboration in a spectrum of areas of NDE including aging aircraft, information networking, etc.

**ROBERTO OSEGUEDA VISIT THE NDE&AA LAB** - In July, Roberto Osegueda, the director of FAST Center at the University of Texas at El Paso, visited JPL in July. JPL and UTEP currently have a joint contract from AFOSR. During his visit Osegueda was given a demonstration of the recent progress that the NDE&AA Lab made in the areas of NDE of composites, NDE of aging aircraft technology, MACS, as well as in the use of piezoelectric and electrostrictive materials for actuation applications.

**NDE OF MICROELECTONICS FOR THE NEW MILENNIUM PROGRAM** (Barela, D'Agostino and Bar-Cohen) - The JPL's Mars Microprobe is entirely an application of micro-electronics. The probe is an assembly of various high-density packaging integrated with a unified high-density interconnect scheme. NDE is critical to the success of this application. JPL took an initiative to develop effective NDE techniques and qualified procedures of assuring the quality of the elements of its electronic assemblies. This effort is going to be funded partially by the NDE Program of Code Q in FY'97. In addition to benefiting the Mars Microprobe, advancement of the NDE technology into the field of high-density electronic packaging and interconnection will serve all of NASA's future missions including Micro-electronic Mechanical Systems (MEMS) that is currently considered for implementation in a wide range of applications. The Microprobe will experience very high accelerations as it enters the Martian atmosphere

and as it impacts the surface of Mars. It is estimated that this acceleration will be on the order of 10,000 G's at the forward body and possibly up to 80,000 G's for the aft body. To successfully design electronic packages for "high G" applications, it is of the utmost importance that all the details of assembly be verified.

### **JSC**

*Marie Havican, 713-483-7134  
mhavican@gp101.jsc.nasa.gov*

### **JSC TECHNOLOGY OUTREACH EFFORT -**

JSC is planning a major event, scheduled for three days in November 1996, to reach out to industry and businesses that are not normally part of the space-oriented community. It is called JSC INSPECTION, and will consist of up to 3000 invited people, with 500 guests for each half-day visit. The objectives of the JSC Inspection are decidedly different from those of an open house; we will showcase technology that may have commercial applications. Some of the major objectives are:

1. Communicate the results of our work to give businesses ideas about how they can use our technology to do what they do better or more profitably.
2. Exhibit work that could interest a firm in partnering with us in dual-use technology development.
3. Showcase JSC-developed technologies that are available for licensing.
4. Display unique facilities that could be used on a reimbursable basis.

### **KSC**

*John Larson, 407-867-3423  
john.larson-1@kmail.ksc.nasa.gov*

**KSC NDE LAB COLLABORATION WITH JPL, LaRC, LeRC and MSFC** - Recent activities at KSC include cooperative support efforts with JPL, LeRC, LaRC and MSFC. All efforts involve utilization of the KSC's Computed Tomography system providing additional data to ongoing studies. Support to a JPL - LeRC effort involved CT scans of a composite being utilized in development of ultrasonic techniques. Support to LaRC involved CT analyses of crystal growth

experiments flown on STS-78. Data produced included digital radiographs, CT slices and 3D images. Information gained from the data provided to LaRC has resulted in MSFC requesting similar analyses on six samples. The support to MSFC is in process. If the data proves as significant, ESA has expressed an interest in obtaining similar analyses.

### **LaRC**

*Eric Madaras, 804-864-4993*

*Eric\_Madaras@qmgate.larc.nasa.gov*

**NEW TECHNIQUE DEVELOPED TO MEASURE RELAXATION PROCESSES IN POLYMERS** (Yost) - A new more accurate technique to measure relaxation processes in polymers has been developed. This technique permits contactless measurement of ultrasonic attenuation whose temperature dependence is useful in the study of internal friction in polymers and metals. It is also expected to give additional insights into aging and service life effects in metals and polymers.

### **DEMONSTRATION OF LOW COST NDE AT STODDARD HAMILTON AIRCRAFT, Inc.**

(Cramer) - A low cost thermal NDE technique developed by the Nondestructive Evaluation Sciences Branch was successfully demonstrated at Stoddard Hamilton Aircraft, Inc. in Arlington, Washington, on June 12 and 13, 1996. The technique uses a commercially available device, designed for medical imaging, that uses temperature sensitive liquid crystal sheets to sense the temperature changes that occur in fiberglass wing and fuselage components as they are actively heated by quartz lamps. The resulting images can be recorded either digitally or photographically for archival purposes. Inspections were made on three different aircraft at several fuselage and wing locations of concern for the manufacturer.

### **MEASUREMENT SYSTEM DELIVERED TO CLINICAL PARTNER** (Yost and Cantrell) - A

measurement system which uses ultrasonics to identify key tissue types in patients with bedsores was delivered to George Taler at Deaton Hospital in Baltimore, Maryland. The researchers also have

identified the bedsore-related tissue types and their transition zones from unique ultrasonic signatures obtained with this system. The instrument is based on LaRC-developed instrumentation designed for nondestructive analysis of polymeric matrix composite materials.

### **INTRACRANIAL PRESSURE (ICP)**

**STUDIES FUNDED BY ARMY** (Cantrell and Yost) - The joint Langley-Ames effort to develop in ultrasonic technique for the noninvasive measurement of intracranial pressure in humans has received a boost from the Army, with the announcement of award of the proposal, "Noninvasive Intracranial Volume and Pressure Measurements Using Ultrasound". The proposal will fund Alan Hargens' group to test the instrumentation at Ames Research Center. The effort will result in a design for a field ready noninvasive ICP monitoring system for the Army.

### **MEETING OF ASTM COMMITTEE E-7 ON NONDESTRUCTIVE TESTING** (Hinton) -

Yolanda Hinton attended a meeting of ASTM Committee E-7 on Nondestructive Testing, where she chairs Subcommittee E07.04 Acoustic Emission. The committee is responsible for more than 130 standards on different methods of nondestructive testing and their applications. The committee maintains liaison with DoD for the conversion of Defense standards to commercial ones. In light of the new law that requires government agencies to use commercial standards where available, the committee will seek formal liaison with NASA as well. The Acoustic Emission subcommittee is planning the Fifth International Symposium on Acoustic Emission: Acoustic Emission Standards and Technology Update, for January 1998.

### **VISIT BY PERSONNEL OF McDONNELL DOUGLAS AND KRAUTKRAMER**

**BRANSON** (Namkung) - Bruce Bates of McDonnell Douglas visited NESB on May 20, 1996, to learn the technical details of the various versions of the self-nulling eddy current sensor prototype instruments. He was particularly interested in the simplicity in the operation of the

rotating self-nulling probe and is looking forward to receiving a prototype unit from NESB for an extensive evaluation. He was met by Mr. Art Leach of Krautkramer Branson, commercialization partner of the self-nulling probe, who brought a recently modified CrackFinder with the adjustable gain control feature. Mr. Bates was pleased to see the progress in the CrackFinder and provided comments for further improvement. He also invited the key individuals in the E&M group to visit the MD facility to try the rotating probe such that its applicability can be clearly defined for the real world test environment.

### **ACOUSTIC EMISSION MONITORING OF SIMULATED MICROMETEOROID IMPACTS ON X-33 COMPOSITE**

**MATERIALS** (Prosser and Humes) - Acoustic Emission (AE) was used to monitor high velocity impact tests of composite plates for Lockheed-Martin as part of the X-33 program. Composites of the minimum and maximum thickness currently designed for cryogenic fuel tanks were tested. A two stage, light gas gun was used to create impacts at velocities ranging from 2 to 6 km/sec. with 1.5 mm diameter nylon projectiles. Preliminary analysis indicates that penetrating impacts can be clearly differentiated from nonpenetrating impacts based on AE signal characteristics. These tests also provide a basis for calculating desired sensor spacing for an on-orbit micrometeoroid and space debris impact monitoring system.

### **ACOUSTIC EMISSION MONITORING OF NORTHROP/ROCKWELL RLV WINGBOX TEST**

(Prosser) - Acoustic Emission (AE) was used to monitor damage progression during the static load testing of the Northrop/ Rockwell RLV composite wingbox test article. Fourteen sensors were monitored, eight using a NASA LaRC AE system and six with a similar Northrop system. The regions monitored by these sensors were the upper wingskin and a portion of the middle spar flange. The cantilevered wingbox was pushed up to limit and ultimate loads, pulled down to limit and ultimate loads, and then at a later date, the wingbox was pushed up to failure. When the specimen was pulled down, the area monitored by

AE was in tension and AE activity was much higher. These AE signals were characteristic of matrix cracking, but the actual damage mechanism was not confirmed. When the wingbox was pushed up and the region monitored was under compression, the level of AE was very low, even up to failure. Although the actual signal from ultimate failure was easily detected and localized, AE signals were not detected from this location before failure to provide prior warning. There are several reasons for this including the sudden, catastrophic failure behavior of composites under compression, the relatively large distance of the failure site from the nearest sensor position, and the low signal gain settings. Northrop determined sensor positions and signal gain based on previous tests of smaller compression test panels.

**PATENT AWARDED** (Zalameda) - Patent No. 5,508,546, "Active Pyroelectric Infrared Detector" by Joseph N. Zalameda, Allan Zuckerwar, and Joseph Mina was awarded April 16, 1996.

**SAM RUSSELL VISITS NESB** (Heath 44964) - Sam Russell of MSFC (Marshall Space Flight Center) visited NESB (Nondestructive Evaluation Sciences Branch) on May 6, 1996. The day was spent discussing current cooperative efforts and planning future directions in thermographic NDE for the Code Q program. Elements of the NESB developed thermography system were identified as important for MSFC applications, and plans for transferal of the LaRC technology to Marshall's newly started thermography program were discussed. Russell also met with Ed Generazio, Code Q NDE Program Manager, to discuss the successes of MSFC's Thermographic and Shearographic NDE RTOPS.

### **NEW VERSION OF CRACKFINDER**

**BECOMES AVAILABLE** (Namkung) - The hand-held CrackFinder, which has been commercially available to date, had an excessive detection sensitivity since the manufacturer, Krautkramer Branson, wanted to emphasize its detectability of extremely shallow surface cracks. It turned out that such a high sensitivity, however, creates more difficulties related to probe wobble

and liftoff, significantly reducing its practical applicability. Upon the suggestions made by the individuals of the NESB Electromagnetics Group, the firm finally produced a prototype with a variable gain. This prototype can be configured as a sliding probe rapidly detecting almost invisible fatigue cracks in the lap joints without being affected by probe wobbles and a sensitive probe that can detect shallow surface cracks. The new probe has been presented to General Dailey during his visit to LaRC, and was shown to Bruce Bates, McDonnell Douglas during his visit to NESB on May 20, 1996.

**ENGINE TITANIUM CONSORTIUM OPEN FORUM** (Johnston) - Patrick Johnston of the Nondestructive Evaluation Science Branch participated in an Open Forum of the Engine Titanium Consortium, sponsored by the FAA Technical Center and FAA New England Engine and Propeller Directorate, in San Francisco, California, on May 8-10, 1996. The Forum presentations focused on recent developments and planned activities toward improvement of inspection of titanium billets and forging for hard alpha inclusions, which can lead to catastrophic failure of jet engine components if not detected. The primary methodology for inspecting the bulk material is ultrasonics, with eddy current testing employed for detecting surface cracks. Areas were identified where NASA developments in ultrasonic array technology, eddy current technology, and radiography might play constructive roles. Contacts were made for follow-up.

**U. S. ARMY LOGISTICS SCHOOL NONDESTRUCTIVE INSPECTION PROGRAM VISITS NESB** (Anastasi, Cmar, Hinton, Roberts, and Zalameda) - On April 22, 1996, the Nondestructive Inspection program of the U. S. Army Logistics School, Fort Eustis, Virginia, visited the Nondestructive Evaluation Sciences Branch's Bob Anastasi, Noreen Cmar, Yolanda Hinton, Mark Roberts, and Joe Zalameda. The purpose of their visit was to tour our facilities and to discuss inspection concerns. An overview talk was given by branch head Ed Generazio and laboratory demonstrations were given by Bob

Anastasi, Noreen Cmar, Pat Johnston, Min Namkung, and Joe Zalameda.

**NESB MEMBERS VISIT U. S. ARMY COMBINED ARMS SUPPORT COMMAND** (Zalameda, Hinton and Farley) - Joe Zalameda, Yolanda Hinton, and Gary Farley visited the U. S. Army Combined Arms Support Command (CASCOM) at Fort Lee, Virginia, on May 2, 1996. They discussed a proposed joint program to develop, evaluate, and demonstrate a nondestructive diagnostic tool for the detection of potential failures in powertrain components of Army vehicles. The system would use chosen NDE methods to characterize signatures from the components, and monitor changes in these signatures as indication of impending failure.

**VISITORS FROM ARINC ARE BRIEFED ON ASIP CORROSION PROGRAM.** (Cramer)- John Alcott and Christian O'Keefe visited NESB on May 1-2, 1996, to discuss progress that has been made on quantification of corrosion in thin aluminum skins. ARINC is currently investigating research into corrosion detection and quantification for Tinker Air Force Base. Discussions and demonstrations were made by researchers in the areas of Thermal, Ultrasonic, and Eddy Current NDE.

**DELTATHERM TECHNOLOGY DEMONSTRATED ON GENERAL AVIATION COMPONENTS FOR RAYTHEON AIRCRAFT** (Cramer) - Steve Hagerott and Bryce Boe from Raytheon Aircraft visited NESB on May 2-3, 1996, to view tests being conducted on Raytheon general aviation aircraft parts as a demonstration of the capabilities of the DeltaTherm 1000. The DeltaTherm 1000 was developed under an SBIR by Stress Photonics, Inc. and is currently being used by NESB researchers for thermoelastic stress imaging. The results obtained during the current testing will be compared with finite element models generated by Raytheon to determine the feasibility of using the DeltaTherm 1000 as a design verification tool for general aviation aircraft. This interaction demonstrates the transfer of ASIP developed

technology for use in other NASA and commercial programs such as the AGATE Program.

**VISITING NDE SCIENTIST FROM GENERAL ELECTRIC** (Namkung) - James P. Fulton of General Electric Corporate Research and Development Center visited NESB (Nondestructive Evaluation Sciences Branch) Electromagnetic Group during the period April 25-May 1, 1996, to perform joint laboratory experiments necessary to gain a deeper insight into various phenomena involved in eddy current NDE. The current mutual interest is to define and enhance the fatigue crack detectability of self-nulling eddy current probes for objects having different electric conductivity and magnetic permeability without being affected by probe wobble. A series of experiments were performed and the results were reported at the QNDE Conference held in July 1996. Another subject of mutual investigation is to clarify the issues related to the dynamics of electromagnetic field inside a conducting medium. A new approach to this problem has been discussed and the steps of systematic investigation have been established.

### **LeRC**

*George Baaklini, 216-433-6016  
george.y.baaklini@lerc.nasa.gov  
or D. J. Roth, 216-433-6017*

### **SINGLE TRANSDUCER ULTRASONIC IMAGING METHOD FOR THICKNESS-INDEPENDENT VELOCITY**

#### **MEASUREMENTS WINS 1996 R&D100**

**AWARD** - Don Roth has commercialized this method under a cooperative agreement between NASA Lewis Research Center and Sonix, Inc. The use of this method can result in significant cost savings during material development. Added precision thickness machining are no longer needed to satisfy nondestructive ultrasonic characterization. Images obtained using the thickness-independent methodology were compared with **apparent** velocity maps and c-scan echo peak amplitude images for monolithic ceramic, metal matrix composite and polymer matrix composite materials having thickness and global microstructural variations.

Results showed that the thickness-independent ultrasonic images reveal and quantify **true** areas of global microstructural variations like pore and fiber volume fraction due to the elimination of thickness effects.

### **MSFC**

*Sam Russell 205-544-4411, sam.russell@msfc.nasa.gov*  
**NDE INSPECTION SPECIFICATIONS** (Sam Russell) - At the request of Mr. Chris Davis of KSC, the first and second drafts of the "Shuttle Orbiter Thermography Inspection Specification" were reviewed and edited. Changes were transmitted to A. M. Koshi of Rockwell International, the document's author. Also, a first draft of a "Shuttle Orbiter Shearography Inspection Specification" has been sent to us for editing.

**NDE OF XCRV COMPOSITE PANELS** (Sam Russell) - This effort is to help JSC decide the method and detectability limits to use to inspect the Assured Crew Return Vehicle (XCRV) aeroskin and other composite components. At the request of Mr. David Stanley of JSC, 12 graphite-epoxy panels which contained programmed defects were inspected with flash and through heated thermography. The face sheet panel contained defects at Teflon inclusions of 2, 1, 0.5, or 0.25 inches in diameter, one of each size placed at depth of 10, 30, or 50 % of the thickness (0.075 in.) of the panel. This panel was inspected from each side and hence detectability of defects using thermography from diameters 2 inches to 0.25 inches and located from 10% to 90% of the thickness was successfully determined. The other 11 panels were graphite skin with Nomex core similar to the Shuttle Payload Door material which contained programmed defects at the honeycomb to skin interface. One of these was a calibration panel which came with a defect map. All panels were inspected and all programmed defects in the calibration panel were detected. Thermography images and defect maps were provided to Mr. Stanley. Shearography and ultrasonic inspection are also being performed on these panels.  
**ATD INSULATION INSPECTION** (Sam Russell) - The advanced turbopump insulation is to

be formed by DuPont on the metal housings at their facility in Newark, Del. The housing's insulation is composed of a layer of chopped Kevlar fiber urethane insulation (KFUI) between two layers of Kevlar cloth and urethane. Each bondline must be inspected and hence inspection is best performed after application of each layer. Inspection of a test bottle covered with KFUI containing programmed defects with shearography and vacuum stressing several years ago was successful. Hence shearography is the leading candidate for inspection. DuPont does not have a shearography system and plans to ship the first few housings to Laser Technology Inc. (LTI) for inspection at intermediate steps. MSFC has two shearography systems and plans to loan a system to DuPont for the two year program. This would enable inspection to be performed more frequently in the process and would eliminate potential shipping induced damage. Pratt and Whitney (P&W), the prime contractor has committed to work an equitable adjustment to the ATD contract for the loan of the MSFC shearography system to DuPont. DuPont has a FLIR Thermographic camera and X-radiographic capability that might be used for inspection of some of the other insulation pieces not bonded to the housings. DuPont is to make test panels containing defects and ship them to MSFC. MSFC NDE will evaluate the panels with shearography, thermography, and radiography and make recommendations to DuPont regarding the best inspection methods for each insulation type.

#### **DEVELOPMENT OF NDE FOR FRICTION STIR WELDING (FSW) RTOP STATUS**

(Linda Clark and Mike Suits) - Inputs from NDE, Quality and Welding personnel at MSFC have been compiled to generate a schedule detailing the tasks to be completed under the RTOP. Lockheed Martin (LM) at Michoud Assembly Facility (MAF) is currently working a Special Development Study (SDS) which involves the development of the FSW plug repair process. The RTOP at MSFC will include support for the FSW plug repair process, development of linear FSW repair welds, and the fabrication of NDE standards for both processes. MSFC and LM personnel have compared

schedules and tasks in an effort to integrate the NDE work proposed in both the RTOP and SDS. An assessment of the NDE capabilities and equipment of MSFC and LM was used to assign the NDE tasks to be completed for both the RTOP and SDS. MSFC and LM personnel are working together to decide what work will be subcontracted. MSFC and LM personnel are in the process of assessing the amount of 2195 aluminum-lithium material (along with various thickness) available in an effort to determine how much additional material needs to be procured. As soon as this assessment is complete, work will begin to support both the RTOP and SDS. A meeting was held on July 31, 1996 at MSFC to finalize the integration of both the RTOP and SDS schedules. MSFC's Welding Group is in the process of becoming a member of the Group Sponsored Project (GSP) in an effort to obtain results from the Phase III work completed at The Weld Institute (TWI). Phase III work involves NDE of the FSW process on 2219 aluminum.

#### **COMING EVENTS**

- Structures, Atlanta, GA., Director S.N. Atluri.
- Oct. 14-18, 1996 - ASNT Fall Conference - Seattle, Washington, ASNT Headquarters, 614-274-6004.
- Dec. 3-5, 1996 - NDE Techniques for Aging Infrastructure & Manufacturing, Scottsdale, AZ. Spie@spie.org, <http://www.spie.org/>
- Dec. 8-13, 1996 - 14th World Conference on NDT - New Delhi, India, Baldev Raj, 04117-40301.
- Feb., 1997 - 4<sup>th</sup> NNWG Workshop - JPL, California, George Baaklini, 216-433-6016.
- Feb. 26-28, 1997 - Golden Gate Materials Technology Conference, San Francisco, CA, Jerry Wittneauer 415-424-2243.

JPL's Mars Pathfinder mission is scheduled for launch on Dec. 2, 1996 and to land on Mars on July 4, 1997. Composite components of this lander were tested at the JPL's NDE & AA Lab.



***NASA NDE Working Group (NNWG) Newsletter***

Editor: Yoseph Bar-Cohen, JPL  
Assistant Editor: Marie Havican, JSC

This NNWG Newsletter is published quarterly by the NNWG and NASA HQ, Code Q.

NASA HQ, Code Q NDE Program Manager: Edward Generazio, LaRC.

**All communications should be addressed to:  
NNWG Newsletter, JPL, M.S. 82-105, 4800 Oak Grove Dr., Pasadena, CA 91109-8099  
Phone: (818)-354-2610, FAX (818)-393-4057 or E-mail: [yosi@jpl.nasa.gov](mailto:yosi@jpl.nasa.gov)**